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WHAT IS CLAIMED IS:

5

1. A method for embedding digital watermark data in digital data contents, said method comprising the steps of:

10 receiving said digital data contents and said digital watermark data;

dividing said digital data contents into block data;

obtaining a frequency coefficient of said block data;

15 obtaining a complexity of said block data;

obtaining an amount of transformation of said frequency coefficient from said complexity and said digital watermark data by using a quantization width;

20 embedding said digital watermark data in said digital data contents by transforming said frequency coefficient by said amount; and

generating watermarked digital data contents.

25

2. The method as claimed in claim 1, said step of obtaining said complexity of said block data comprising the steps of:

30 transforming said block data, by applying a wavelet transform, into coefficients of said wavelet transform, and

35 obtaining said complexity on the basis of the number of high frequency coefficients in said coefficients of said wavelet transform, each of said

high frequency coefficients exceeding a threshold.

5

3. A method for embedding digital watermark data in digital data contents, said method comprising the steps of:

10 receiving said digital data contents and said digital watermark data;  
dividing said digital data contents into block data;

obtaining a frequency coefficient of said block data;

15 obtaining an amount of transformation of said frequency coefficient from said digital watermark data by using a quantization width corresponding to said frequency coefficient, said quantization width being obtained beforehand  
20 according to a manipulation method of said digital data contents;

embedding said digital watermark data in said digital data contents by transforming said frequency coefficient by said amount; and  
25 generating watermarked digital data contents.

30

4. The method as claimed in claim 3, wherein said quantization width is obtained by a method comprising the steps of:

35 dividing first digital data contents into one or a plurality of first block data;

dividing second digital data contents into one or a plurality of second block data, said second

digital data contents being obtained by manipulating said first digital data contents with a predetermined manipulation method;

transforming said first block data and  
5 said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal transform;

obtaining difference values between said first frequency coefficients and said second  
10 frequency coefficients for each frequency coefficient;

calculating a standard deviation of distribution of said difference values; and

obtaining said quantization width by  
15 multiplying said standard deviation by a watermark embedding strength.

20

5. A method for reading digital watermark data embedded in digital data contents, said method comprising the steps of:

receiving said digital data contents;

25 dividing said digital data contents into block data;

obtaining a frequency coefficient of said block data; and

generating digital watermark data from  
30 said frequency coefficient by using a quantization width corresponding to said frequency coefficient, said quantization width being obtained beforehand according to a manipulation method of said digital data contents.

35

6. The method as claimed in claim 5, wherein said quantization width is obtained by a method comprising the steps of:

- 5           dividing first digital data contents into one or a plurality of first block data;
- dividing second digital data contents into one or a plurality of second block data, said second digital data contents being obtained by manipulating
- 10       said first digital data contents with a predetermined manipulation method;
- transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients
- 15       respectively by applying an orthogonal transform;
- obtaining difference values between said first frequency coefficients and said second frequency coefficients for each frequency coefficient;
- 20       calculating a standard deviation of distribution of said difference values; and
- obtaining said quantization width by multiplying said standard deviation by a watermark embedding strength.
- 25

7. An apparatus for embedding digital watermark data in digital data contents, said apparatus comprising:

- 30           means for receiving said digital data contents and said digital watermark data;
- means for dividing said digital data
- 35       contents into block data;
- means for obtaining a frequency coefficient of said block data;

means for obtaining a complexity of said block data;

means for obtaining an amount of transformation of said frequency coefficient from  
5 said complexity and said digital watermark data by using a quantization width;

means for embedding said digital watermark data in said digital data contents by transforming said frequency coefficient by said amount; and

10 means for generating watermarked digital data contents.

15

8. The apparatus as claimed in claim 7, said means for obtaining said complexity of said block data comprising:

means for transforming said block data, by  
20 applying a wavelet transform, into coefficients of said wavelet transform, and

means for obtaining said complexity on the basis of the number of high frequency coefficients in said coefficients of said wavelet transform, each  
25 of said high frequency coefficients exceeding a threshold.

30

9. An apparatus for embedding digital watermark data in digital data contents, said apparatus comprising:

means for receiving said digital data  
35 contents and said digital watermark data;

means for dividing said digital data contents into block data;

means for obtaining a frequency  
coefficient of said block data;

means for obtaining an amount of  
transformation of said frequency coefficient from  
5 said digital watermark data by using a quantization  
width corresponding to said frequency coefficient,  
said quantization width being obtained beforehand  
according to a manipulation method of said digital  
data contents;

10 means for embedding said digital watermark  
data in said digital data contents by transforming  
said frequency coefficient by said amount; and

means for generating watermarked digital  
data contents.

15

10. The apparatus as claimed in claim 9,  
20 wherein said quantization width is obtained by means  
comprising:

means for dividing first digital data  
contents into one or a plurality of first block  
data;

25 means for dividing second digital data  
contents into one or a plurality of second block  
data, said second digital data contents being  
obtained by manipulating said first digital data  
contents with a predetermined manipulation method;

30 means for transforming said first block  
data and said second block data into first frequency  
coefficients and second frequency coefficients  
respectively by applying an orthogonal transform;

means for obtaining difference values  
35 between said first frequency coefficients and said  
second frequency coefficients for each frequency  
coefficient;

means for calculating a standard deviation of distribution of said difference values; and

means for obtaining said quantization width by multiplying said standard deviation by a  
5 watermark embedding strength.

10 11. An apparatus for reading digital watermark data embedded in digital data contents, said apparatus comprising:

means for receiving said digital data contents;

15 means for dividing said digital data contents into block data;

means for obtaining a frequency coefficient of said block data; and

means for generating digital watermark  
20 data from said frequency coefficient by using a quantization width corresponding to said frequency coefficient, said quantization width being obtained beforehand according to a manipulation method of said digital data contents.

25

12. The apparatus as claimed in claim 11,  
30 wherein said quantization width is obtained by means comprising:

means for dividing first digital data contents into one or a plurality of first block data;

35 means for dividing second digital data contents into one or a plurality of second block data, said second digital data contents being



obtained by manipulating said first digital data contents with a predetermined manipulation method;  
means for transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients  
5 respectively by applying an orthogonal transform;  
means for obtaining difference values between said first frequency coefficients and said second frequency coefficients for each frequency  
10 coefficient;  
means for calculating a standard deviation of distribution of said difference values; and  
means for obtaining said quantization width by multiplying said standard deviation by a  
15 watermark embedding strength.

20 13. An integrated circuit for embedding digital watermark data in digital data contents, said integrated circuit comprising:  
means for receiving said digital data contents and said digital watermark data;  
25 means for dividing said digital data contents into block data;  
means for obtaining a frequency coefficient of said block data;  
means for obtaining a complexity of said  
30 block data;  
means for obtaining an amount of transformation of said frequency coefficient from said complexity and said digital watermark data by using a quantization width;  
35 means for embedding said digital watermark data in said digital data contents by transforming said frequency coefficient by said amount; and

means for generating watermarked digital data contents.

5

14. The integrated circuit as claimed in claim 13, said means for obtaining said complexity of said block data comprising:

10 means for transforming said block data, by applying a wavelet transform, into coefficients of said wavelet transform, and

means for obtaining said complexity on the basis of the number of high frequency coefficients in said coefficients of said wavelet transform, each of said high frequency coefficients exceeding a threshold.

20

15. An integrated circuit for embedding digital watermark data in digital data contents, said integrated circuit comprising:

25 means for receiving said digital data contents and said digital watermark data;

means for dividing said digital data contents into block data;

30 means for obtaining a frequency coefficient of said block data;

means for obtaining an amount of transformation of said frequency coefficient from said digital watermark data by using a quantization width corresponding to said frequency coefficient, said quantization width being obtained beforehand according to a manipulation method of said digital data contents;

means for embedding said digital watermark data in said digital data contents by transforming said frequency coefficient by said amount; and

5 means for generating watermarked digital data contents.

10 16. The integrated circuit as claimed in claim 15, wherein said quantization width is obtained by means comprising:

means for dividing first digital data contents into one or a plurality of first block data;

15 means for dividing second digital data contents into one or a plurality of second block data, said second digital data contents being obtained by manipulating said first digital data contents with a predetermined manipulation method;

20 means for transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal transform;

25 means for obtaining difference values between said first frequency coefficients and said second frequency coefficients for each frequency coefficient;

30 means for calculating a standard deviation of distribution of said difference values; and

means for obtaining said quantization width by multiplying said standard deviation by a watermark embedding strength.

35

17. An integrated circuit for reading digital watermark data embedded in digital data contents, said integrated circuit comprising:

5 means for receiving said digital data contents;

means for dividing said digital data contents into block data;

means for obtaining a frequency coefficient of said block data; and

10 means for generating digital watermark data from said frequency coefficient by using a quantization width corresponding to said frequency coefficient, said quantization width being obtained beforehand according to a manipulation method of  
15 said digital data contents.

20 18. The integrated circuit as claimed in claim 17, wherein said quantization width is obtained by means comprising:

25 means for dividing first digital data contents into one or a plurality of first block data;

means for dividing second digital data contents into one or a plurality of second block data, said second digital data contents being obtained by manipulating said first digital data  
30 contents with a predetermined manipulation method;

means for transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal transform;

35 means for obtaining difference values between said first frequency coefficients and said second frequency coefficients for each frequency

coefficient;

means for calculating a standard deviation of distribution of said difference values; and

means for obtaining said quantization width by multiplying said standard deviation by a watermark embedding strength.

10

19. A computer readable medium storing program code for causing a computer system to embed digital watermark data in digital data contents, said computer readable medium comprising:

15 program code means for receiving said digital data contents and said digital watermark data;

program code means for dividing said digital data contents into block data;

20 program code means for obtaining a frequency coefficient of said block data;

program code means for obtaining a complexity of said block data;

25 program code means for obtaining an amount of transformation of said frequency coefficient from said complexity and said digital watermark data by using a quantization width;

30 program code means for embedding said digital watermark data in said digital data contents by transforming said frequency coefficient by said amount; and

program code means for generating watermarked digital data contents.

35

20. The computer readable medium as claimed in claim 19, said program code means for obtaining said complexity of said block data comprising:

- 5           program code means for transforming said block data, by applying a wavelet transform, into coefficients of said wavelet transform, and  
            program code means for obtaining said complexity on the basis of the number of high  
10 frequency coefficients in said coefficients of said wavelet transform, each of said high frequency coefficients exceeding a threshold.

15

21. A computer readable medium storing program code for causing a computer system to embed digital watermark data in digital data contents,  
20 said computer readable medium comprising:

- program code means for receiving said digital data contents and said digital watermark data;  
            program code means for dividing said  
25 digital data contents into block data;  
            program code means for obtaining a frequency coefficient of said block data;  
            program code means for obtaining an amount of transformation of said frequency coefficient from  
30 said digital watermark data by using a quantization width corresponding to said frequency coefficient, said quantization width being obtained beforehand according to a manipulation method of said digital data contents;  
35           program code means for embedding said digital watermark data in said digital data contents by transforming said frequency coefficient by said

amount; and

program code means for generating  
watermarked digital data contents.

5

22. The computer readable medium as  
claimed in claim 21, wherein said quantization width  
10 is obtained by program code means comprising:

program code means for dividing first  
digital data contents into one or a plurality of  
first block data;

program code means for dividing second  
15 digital data contents into one or a plurality of  
second block data, said second digital data contents  
being obtained by manipulating said first digital  
data contents with a predetermined manipulation  
method;

20 program code means for transforming said  
first block data and said second block data into  
first frequency coefficients and second frequency  
coefficients respectively by applying an orthogonal  
transform;

25 program code means for obtaining  
difference values between said first frequency  
coefficients and said second frequency coefficients  
for each frequency coefficient;

30 program code means for calculating a  
standard deviation of distribution of said  
difference values; and

program code means for obtaining said  
quantization width by multiplying said standard  
deviation by a watermark embedding strength.

35

23. A computer readable medium storing  
program code for causing a computer system to read  
digital watermark data embedded in digital data  
5 contents, said computer readable medium comprising:  
program code means for receiving said  
digital data contents;  
program code means for dividing said  
digital data contents into block data;  
10 program code means for obtaining a  
frequency coefficient of said block data; and  
program code means for generating digital  
watermark data from said frequency coefficient by  
using a quantization width corresponding to said  
15 frequency coefficient, said quantization width being  
obtained beforehand according to a manipulation  
method of said digital data contents.

20

24. The computer readable medium as  
claimed in claim 23, wherein said quantization width  
is obtained by program code means comprising:  
25 program code means for dividing first  
digital data contents into one or a plurality of  
first block data;  
program code means for dividing second  
digital data contents into one or a plurality of  
30 second block data, said second digital data contents  
being obtained by manipulating said first digital  
data contents with a predetermined manipulation  
method;  
program code means for transforming said  
35 first block data and said second block data into  
first frequency coefficients and second frequency  
coefficients respectively by applying an orthogonal



transform;

program code means for obtaining  
difference values between said first frequency  
coefficients and said second frequency coefficients  
5 for each frequency coefficient;

program code means for calculating a  
standard deviation of distribution of said  
difference values; and

10 program code means for obtaining said  
quantization width by multiplying said standard  
deviation by a watermark embedding strength.

15

25. A method for reading digital watermark  
data embedded in digital data contents, said method  
comprising the steps of:

receiving said digital data contents;  
20 reading a bit sequence from said digital  
data contents;

calculating a probability of reading a bit  
'1' or a bit '0' in said bit sequence by using a  
test method on the basis of binary distribution;

25 determining the presence or absence of  
digital watermark data according to said  
probability; and

reconstituting and generating said digital  
watermark data from said bit sequence.

30

26. The method as claimed in claim 25,  
35 further comprising the steps of:

determining threshold  $\alpha$  of reliability of  
digital watermark data which is read;

obtaining a binary distribution function  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits are included in a bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a repeating number of embedding each bit of digital watermark data;

reading an  $i$ th digital watermark sequence of said digital watermark data from a digital watermark area of said digital data contents;

calculating the number  $k_i$  of '1' or '0' included in said digital watermark sequence;

calculating a probability  $F(k_i)$  by using said binary distribution function  $F(x)$ ; and

reconstituting '1' or '0' from  $i$ th digital watermark data  $w_i$  if  $F(k_i) > \alpha$ , reconstituting '0' or '1' from  $i$ th digital watermark data  $w_i$  if  $1-F(k_i) > \alpha$ , and determining that there is no watermark data or the presence is unknown if both of  $F(k_i) > \alpha$  and  $1-F(k_i) > \alpha$  are not satisfied.

27. The method as claimed in claim 26, further comprising the steps of:

outputting  $F(k_i)$  as reliability if said reconstituted digital watermark data  $w_i$  is '1'; and outputting  $1-F(k_i)$  as the reliability if said reconstituted digital watermark data  $w_i$  is '0'.

28. The method as claimed in claim 25,

further comprising the steps of:

determining a threshold  $\alpha$  of reliability of digital watermark data which is read;

obtaining a binary distribution function  
5 F(x) which represents a probability that a number x of '1' bits or '0' bits are included in a bit sequence which is read at random from digital data contents, said binary distribution function F(x) being obtained by using a probability q of reading  
10 '1' or '0' in said bit sequence and a repeating number of embedding each bit of digital watermark data;

reading an ith digital watermark sequence of said digital watermark data from a digital  
15 watermark area of said digital data contents;

checking whether a probability that said digital watermark sequence is digital watermark data exceeds said threshold  $\alpha$  by using said binary distribution function F(x); and

20 reconstituting digital watermark data from said digital watermark sequence by using majority decision processing if said probability exceeds  $\alpha$ , and determining that there is no watermark data or the presence is unknown if said probability does not  
25 exceed  $\alpha$ .

30 29. The method as claimed in claim 28, further comprising a step of outputting said probability that said digital watermark sequence is digital watermark data.

35

30. The method as claimed in claim 25, if  
a data sequence which is embedded as said digital  
watermark data is modulated by a pseudo-random  
sequence, said method further comprising the steps  
5 of:

demodulating said bit sequence by said  
pseudo-random sequence; and

reconstituting digital watermark data from  
said demodulated bit sequence.

10

31. The method as claimed in claim 25, if  
15 a data sequence which is embedded as said digital  
watermark data is modulated by a pseudo-random  
sequence, said method further comprising the steps  
of:

determining a threshold  $\alpha$  of reliability  
20 of digital watermark data which is read;

obtaining a binary distribution function  
 $F(x)$  which represents a probability that a number of  
 $x$  of '1' bits or '0' bits are included in a bit  
sequence which is read at random from digital data  
25 contents, said binary distribution function  $F(x)$   
being obtained by using a probability  $q$  of reading  
'1' or '0' in said bit sequence and a repeating  
number of embedding each bit of digital watermark  
data;

30 reading an  $i$ th digital watermark sequence  
of said digital watermark data from a digital  
watermark area of said digital data contents;

demodulating said digital watermark  
sequence by said pseudo-random sequence;

35 assigning  $1/2$  to said probability  $q$ ;

obtaining a maximum number  $x_0$  which  
satisfies  $0 \leq F(x=x_0) \leq 1-\alpha$  and a minimum number  $x_1$

which satisfies  $\alpha \leq F(x=x_1) \leq 1$ ;  
obtaining the number  $k_i$  of '1' or '0'  
included in said  $i$ th digital watermark sequence; and  
reconstituting  $i$ th digital watermark data  
5  $w_i$  as '0' or '1' if  $k_i \leq x_0$ , and reconstituting said  
 $i$ th digital watermark data  $w_i$  as '1' or '0' if  $k_i \geq x_1$ .

10

32. The method as claimed in claim 25, if  
a data sequence which is embedded as said digital  
watermark data is modulated by a pseudo-random  
sequence, said method further comprising the steps  
15 of:

determining a threshold  $\alpha$  of reliability  
of digital watermark data which is read;  
obtaining a binary distribution function  
 $F(x)$  which represents a probability that  $x$  of '1'  
20 bits or '0' bits are included in a bit sequence  
which is read at random from digital data contents,  
said binary distribution function  $F(x)$  being  
obtained by using a probability  $q$  of reading '1' or  
'0' in said bit sequence and a repeating number  $t$  of  
25 embedding each bit of digital watermark data;  
reading an  $i$ th digital watermark sequence  
of said digital watermark data from a digital  
watermark area of said digital data contents;  
demodulating said digital watermark  
30 sequence by said pseudo-random sequence;  
assigning  $1/2$  to said probability  $q$ ;  
obtaining  $x_0$  or  $x_1$  which satisfies  $0 \leq$   
 $F(x=x_0) \leq 1-\alpha$  or  $\alpha \leq F(x=x_1) \leq 1$ ;  
determining whether a value is equal to or  
35 less than  $x_0$  or equal to or more than  $x_1$ , said value  
being a mean value of absolute values of a  
difference between the number of '0' or '1' included

in said  $i$ th digital watermark sequence and a central value  $q \times t$  of a binary distribution;

reconstituting digital watermark data by performing majority decision processing for said  $i$ th digital watermark sequence if said value is equal to  
5 or less than  $x_0$ , or equal to or more than  $x_1$ ; and

determining that there is no digital watermark data or the presence is unknown if said value is not equal to or less than  $x_0$ , or equal to or  
10 more than  $x_1$ .

15 33. The method as claimed in claim 32, further comprising the steps of:

calculating a value of said binary distribution function  $F(z)$ ,  $z$  being said mean value obtained from the number of '0' or '1' included in  
20 said  $i$ th digital watermark sequence and said central value  $q \times t$ ; and

outputting said value of  $F(z)$  as reliability of digital watermark data.

25

34. An apparatus for reading digital watermark data embedded in digital data contents,  
30 said apparatus comprising:

means for receiving said digital data contents;

means for reading a bit sequence from said digital data contents;

35 means for calculating a probability of reading a bit '1' or a bit '0' in said bit sequence by using a test method on the basis of binary

distribution;

means for determining the presence or absence of digital watermark data according to said probability; and

5 means for reconstituting said digital watermark data from said bit sequence.

10

35. The apparatus as claimed in claim 34, further comprising:

means for obtaining a binary distribution function  $F(x)$  which represents a probability that a  
15 number  $x$  of '1' bits or '0' bits are included in a bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a  
20 repeating number of embedding each bit of digital watermark data;

means for reading an  $i$ th digital watermark sequence of said digital watermark data from a digital watermark area of said digital data  
25 contents;

means for calculating the number  $k_i$  of '1' or '0' included in said digital watermark sequence;

means for calculating a probability  $F(k_i)$  by using said binary distribution function  $F(x)$ ; and

30 means for reconstituting '1' or '0' from  $i$ th digital watermark data  $w_i$  if  $F(k_i) > \alpha$ , reconstituting '0' or '1' from  $i$ th digital watermark data  $w_i$  if  $1-F(k_i) > \alpha$ , and, determining that there is no watermark data or the presence is unknown if  
35 both of  $F(k_i) > \alpha$  and  $1-F(k_i) > \alpha$  are not satisfied,  $\alpha$  being a threshold of reliability of digital watermark data which is read.

5           36. The apparatus as claimed in claim 35,  
further comprising:

          means for outputting  $F(k_i)$  as reliability  
if said reconstituted digital watermark data  $w_i$  is  
'1'; and

10           means for outputting  $1-F(k_i)$  as  
reliability if said reconstituted digital watermark  
data  $w_i$  is '0'.

15

          37. The apparatus as claimed in claim 34,  
further comprising:

          means for obtaining a binary distribution  
20 function  $F(x)$  which represents a probability that a  
number  $x$  of '1' bits or '0' bits are included in a  
bit sequence which is read at random from digital  
data contents, said binary distribution function  
 $F(x)$  being obtained by using a probability  $q$  of  
25 reading '1' or '0' in said bit sequence and a  
repeating number of embedding each bit of digital  
watermark data;

          means for reading an  $i$ th digital watermark  
sequence of said digital watermark data from a  
30 digital watermark area of said digital data  
contents;

          means for checking whether a probability  
that said digital watermark sequence is digital  
watermark data exceeds said threshold  $\alpha$  by using  
35 said binary distribution function  $F(x)$ ,  $\alpha$  being a  
threshold of reliability of digital watermark data  
which is read; and



means for reconstituting and generating digital watermark data from said digital watermark sequence by using majority decision processing if said probability exceeds  $\alpha$ , and, determining that  
5 there is no watermark data or the presence is unknown if said probability does not exceed  $\alpha$ .

10

38. The apparatus as claimed in claim 37, further comprising means for outputting said probability that said digital watermark sequence is digital watermark data.

15

39. The apparatus as claimed in claim 34,  
20 if a data sequence which is embedded as said digital watermark data is modulated by a pseudo-random sequence, said apparatus further comprising:

means for demodulating said bit sequence by said pseudo-random sequence; and

25 means for reconstituting digital watermark data from said demodulated bit sequence.

30

40. The apparatus as claimed in claim 34, if a data sequence which is embedded as said digital watermark data is modulated by a pseudo-random sequence, said apparatus further comprising:

35 means for obtaining a binary distribution function  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits are included in a

bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a  
5 repeating number of embedding each bit of digital watermark data;

means for reading an  $i$ th digital watermark sequence of said digital watermark data from a digital watermark area of said digital data  
10 contents;

means for demodulating said digital watermark sequence by said pseudo-random sequence;

means for assigning  $1/2$  to said probability  $q$ ;

15 means for obtaining a maximum number  $x_0$  which satisfies  $0 \leq F(x=x_0) \leq 1-\alpha$  and a minimum number  $x_1$  which satisfies  $\alpha \leq F(x=x_1) \leq 1$ ,  $\alpha$  being a threshold of reliability of digital watermark data which is read;

20 means for obtaining the number  $k_i$  of '1' or '0' included in said  $i$ th digital watermark sequence; and

means for reconstituting  $i$ th digital watermark data  $w_i$  as '0' or '1' if  $k_i \leq x_0$ , and,  
25 reconstituting said  $i$ th digital watermark data  $w_i$  as '1' or '0' if  $k_i \geq x_1$ .

30

41. The apparatus as claimed in claim 34, if a data sequence which is embedded as said digital watermark data is modulated by a pseudo-random sequence, said apparatus further comprising:

35 means for obtaining a binary distribution function  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits are included in a

bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a  
5 repeating number  $t$  of embedding each bit of digital watermark data;

means for reading an  $i$ th digital watermark sequence of said digital watermark data from a digital watermark area of said digital data  
10 contents;

means for demodulating said digital watermark sequence by said pseudo-random sequence;

means for assigning  $1/2$  to said probability  $q$ ;

15 means for obtaining  $x_0$  or  $x_1$  which satisfies  $0 \leq F(x=x_0) \leq 1-\alpha$  or  $\alpha \leq F(x=x_1) \leq 1$ ,  $\alpha$  being a threshold of reliability of digital watermark data which is read;

means for determining whether a value is  
20 equal to or less than  $x_0$  or equal to or more than  $x_1$ , said value being a mean value of absolute values of a difference between the number of '0' or '1' included in said  $i$ th digital watermark sequence and a central value  $q \times t$  of a binary distribution;

25 means for reconstituting digital watermark data by performing majority decision processing for said  $i$ th digital watermark sequence if said value is equal to or less than  $x_0$  or equal to or more than  $x_1$ ; and

30 means for determining that there is no digital watermark data or the presence is unknown if said value is not equal to or less than  $x_0$  or equal to or more than  $x_1$ .

35

42. The apparatus as claimed in claim 41, further comprising:

means for calculating a value of said binary distribution function  $F(z)$ ,  $z$  being said mean value obtained from the number of '0' or '1' included in said  $i$ th digital watermark sequence and said central value  $q \times t$ ; and

means for outputting said value of  $F(z)$  as reliability of digital watermark data.

10

43. An integrated circuit for reading digital watermark data embedded in digital data contents, said integrated circuit comprising:

means for receiving said digital data contents;

means for reading a bit sequence from said digital data contents;

means for calculating a probability of reading a bit '1' or a bit '0' in said bit sequence by using a test method on the basis of binary distribution;

means for determining the presence or absence of digital watermark data according to said probability; and

means for reconstituting and generating said digital watermark data from said bit sequence.

30

44. The integrated circuit as claimed in claim 43, further comprising:

means for obtaining a binary distribution function  $F(x)$  which represents a probability that a

number  $x$  of '1' bits or '0' bits are included in a bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of  
5 reading '1' or '0' in said bit sequence and a repeating number of embedding each bit of digital watermark data;

means for reading an  $i$ th digital watermark sequence of said digital watermark data from a  
10 digital watermark area of said digital data contents;

means for calculating the number  $k_i$  of '1' or '0' included in said digital watermark sequence;

means for calculating a probability  $F(k_i)$   
15 by using said binary distribution function  $F(x)$ ; and

means for reconstituting '1' or '0' from  $i$ th digital watermark data  $w_i$  if  $F(k_i) > \alpha$ , reconstituting '0' or '1' from  $i$ th digital watermark data  $w_i$  if  $1-F(k_i) > \alpha$ , and determining that there  
20 is no watermark data or the presence is unknown if both of  $F(k_i) > \alpha$  and  $1-F(k_i) > \alpha$  are not satisfied,  $\alpha$  being a threshold of reliability of digital watermark data which is read.

25

45. The integrated circuit as claimed in claim 44, further comprising:

30 means for outputting  $F(k_i)$  as reliability if said reconstituted digital watermark data  $w_i$  is '1'; and

means for outputting  $1-F(k_i)$  as reliability if said reconstituted digital watermark  
35 data  $w_i$  is '0'.

46. The integrated circuit as claimed in claim 43, further comprising:

5 means for obtaining a binary distribution function  $F(x)$  which represents a probability that a number of  $x$  of '1' bits or '0' bits are included in a bit sequence which is read at random from digital data contents, said binary distribution function  
10  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a repeating number of embedding each bit of digital watermark data;

means for reading an  $i$ th digital watermark  
15 sequence of said digital watermark data from a digital watermark area of said digital data contents;

means for checking whether a probability that said digital watermark sequence is digital  
20 watermark data exceeds said threshold  $\alpha$  by using said binary distribution function  $F(x)$ ,  $\alpha$  being a threshold of reliability of digital watermark data which is read; and

means for reconstituting and generating  
25 digital watermark data from said digital watermark sequence by using majority decision processing if said probability exceeds  $\alpha$ , and, determining that there is no watermark data or the presence is unknown if said probability does not exceed  $\alpha$ .

30

47. The integrated circuit as claimed in  
35 claim 46, further comprising means for outputting said probability that said digital watermark sequence is digital watermark data.

5           48. The integrated circuit as claimed in  
claim 43, if a data sequence which is embedded as  
said digital watermark data is modulated by a  
pseudo-random sequence, said integrated circuit  
further comprising:  
10           means for demodulating said bit sequence  
by said pseudo-random sequence; and  
            means for reconstituting digital watermark  
data from said demodulated bit sequence.

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            49. The integrated circuit as claimed in  
claim 43, if a data sequence which is embedded as  
20   said digital watermark data is modulated by a  
pseudo-random sequence, said integrated circuit  
further comprising:  
            means for obtaining a binary distribution  
function  $F(x)$  which represents a probability that a  
25   number  $x$  of '1' bits or '0' bits are included in a  
bit sequence which is read at random from digital  
data contents, said binary distribution function  
 $F(x)$  being obtained by using a probability  $q$  of  
reading '1' or '0' in said bit sequence and a  
30   repeating number of embedding each bit of digital  
watermark data;  
            means for reading an  $i$ th digital watermark  
sequence of said digital watermark data from a  
digital watermark area of said digital data  
35   contents;  
            means for demodulating said digital  
watermark sequence by said pseudo-random sequence;

means for assigning  $1/2$  to said probability  $q$ ;

means for obtaining a maximum number  $x_0$  which satisfies  $0 \leq F(x=x_0) \leq 1-\alpha$  and a minimum number  $x_1$  which satisfies  $\alpha \leq F(x=x_1) \leq 1$ ,  $\alpha$  being a threshold of reliability of digital watermark data which is read; and

means for obtaining the number  $k_i$  of '1' or '0' included in said  $i$ th digital watermark sequence;

means for reconstituting  $i$ th digital watermark data  $w_i$  as '0' or '1' if  $k_i \leq x_0$ , and, reconstituting said  $i$ th digital watermark data  $w_i$  as '1' or '0' if  $k_i \geq x_1$ .

15

50. The integrated circuit as claimed in claim 43, if a data sequence which is embedded as said digital watermark data is modulated by a pseudo-random sequence, said integrated circuit further comprising:

means for obtaining a binary distribution function  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits are included in a bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a repeating number  $t$  of embedding each bit of digital watermark data;

means for reading an  $i$ th digital watermark sequence of said digital watermark data from a digital watermark area of said digital data contents;

means for demodulating said digital



watermark sequence by said pseudo-random sequence;  
means for assigning  $1/2$  to said  
probability  $q$ ;

means for obtaining  $x_0$  or  $x_1$  which  
5 satisfies  $0 \leq F(x=x_0) \leq 1-\alpha$  or  $\alpha \leq F(x=x_1) \leq 1$ ,  $\alpha$  being a  
threshold of reliability of digital watermark data  
which is read;

means for determining whether a value is  
equal to or less than  $x_0$  or equal to or more than  $x_1$ ,  
10 said value being a mean value of absolute values of  
a difference between the number of '0' or '1'  
included in said  $i$ th digital watermark sequence and  
a central value  $q \times t$  of a binary distribution;

means for reconstituting digital watermark  
15 data by performing majority decision processing for  
said  $i$ th digital watermark sequence if said value is  
equal to or less than  $x_0$  or equal to or more than  
 $x_1$ ; and

means for determining that there is no  
20 digital watermark data or the presence is unknown if  
said value is not equal to or less than  $x_0$  or equal  
to or more than  $x_1$ .

25

51. The integrated circuit as claimed in  
claim 50, further comprising:

means for calculating a value of said  
30 binary distribution function  $F(z)$ ,  $z$  being said mean  
value obtained from the number of '0' or '1'  
included in said  $i$ th digital watermark sequence and  
said central value  $q \times t$ ; and

means for outputting said value of  $F(z)$  as  
35 reliability of digital watermark data.

52. A computer readable medium storing  
program code for causing a computer system to read  
5 digital watermark data embedded in digital data  
contents, said computer readable medium comprising:  
program code means for receiving said  
digital data contents;  
program code means for reading a bit  
10 sequence from said digital data contents;  
program code means for calculating a  
probability of reading a bit '1' or a bit '0' in  
said bit sequence by using a test method on the  
basis of binary distribution;  
15 program code means for determining the  
presence or absence of digital watermark data  
according to said probability; and  
program code means for reconstituting and  
generating said digital watermark data from said bit  
20 sequence.

53. The computer readable medium as  
25 claimed in claim 52, further comprising:  
program code means for obtaining a binary  
distribution function  $F(x)$  which represents a  
probability that a number  $x$  of '1' bits or '0' bits  
30 are included in a bit sequence which is read at  
random from digital data contents, said binary  
distribution function  $F(x)$  being obtained by using a  
probability  $q$  of reading '1' or '0' in said bit  
sequence and a repeating number of embedding each  
35 bit of digital watermark data;  
program code means for reading an  $i$ th  
digital watermark sequence of said digital watermark

data from a digital watermark area of said digital data contents;

program code means for calculating the number  $k_i$  of '1' or '0' included in said digital watermark sequence; and

program code means for calculating a probability  $F(k_i)$  by using said binary distribution function  $F(x)$ ;

program code means for reconstituting '1' or '0' from  $i$ th digital watermark data  $w_i$  if  $F(k_i) > \alpha$ , reconstituting '0' or '1' from  $i$ th digital watermark data  $w_i$  if  $1-F(k_i) > \alpha$ , and, determining that there is no watermark data or the presence is unknown if both of  $F(k_i) > \alpha$  and  $1-F(k_i) > \alpha$  are not satisfied,  $\alpha$  being a threshold of reliability of digital watermark data which is read.

20

54. The computer readable medium as claimed in claim 53, further comprising:

program code means for outputting  $F(k_i)$  as reliability if said reconstituted digital watermark data  $w_i$  is '1'; and

program code means for outputting  $1-F(k_i)$  as reliability if said reconstituted digital watermark data  $w_i$  is '0'.

30

55. The computer readable medium as claimed in claim 52, further comprising:

program code means for obtaining a binary distribution function  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits

are included in a bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a repeating number of embedding each bit of digital watermark data;

program code means for reading an  $i$ th digital watermark sequence of said digital watermark data from a digital watermark area of said digital data contents;

program code means for checking whether a probability that said digital watermark sequence is digital watermark data exceeds said threshold  $\alpha$  by using said binary distribution function  $F(x)$ ,  $\alpha$  being a threshold of reliability of digital watermark data which is read; and

program code means for reconstituting and generating digital watermark data from said digital watermark sequence by using majority decision processing if said probability exceeds  $\alpha$ , and determining that there is no watermark data or the presence is unknown if said probability does not exceed  $\alpha$ .

56. The computer readable medium as claimed in claim 55, further comprising program code means for outputting said probability that said digital watermark sequence is digital watermark data as reliability of said reconstituted digital watermark data.

57. The computer readable medium as claimed in claim 52, if a data sequence which is embedded as said digital watermark data is modulated by a pseudo-random sequence, said computer readable  
5 medium further comprising:

program code means for demodulating said bit sequence by said pseudo-random sequence; and

program code means for reconstituting digital watermark data from said demodulated bit  
10 sequence.

15 58. The computer readable medium as claimed in claim 52, if data sequence which is embedded as said digital watermark data is modulated by a pseudo-random sequence, said computer readable medium further comprising:

20 program code means for obtaining a binary distribution function  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits are included in a bit sequence which is read at random from digital data contents, said binary  
25 distribution function  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a repeating number of embedding each bit of digital watermark data;

program code means for reading an  $i$ th  
30 digital watermark sequence of said digital watermark data from a digital watermark area of said digital data contents;

program code means for demodulating said digital watermark sequence by said pseudo-random  
35 sequence;

program code means for assigning  $1/2$  to said probability  $q$ ;

program code means for obtaining a maximum number  $x_0$  which satisfies  $0 \leq F(x=x_0) \leq 1-\alpha$  and a minimum number  $x_1$  which satisfies  $\alpha \leq F(x=x_1) \leq 1$ ,  $\alpha$  being a threshold of reliability of digital watermark data which is read;

5 program code means for obtaining the number  $k_i$  of '1' or '0' included in said  $i$ th digital watermark sequence; and

10 program code means for reconstituting  $i$ th digital watermark data  $w_i$  as '0' or '1' if  $k_i \leq x_0$ , and reconstituting said  $i$ th digital watermark data  $w_i$  as '1' or '0' if  $k_i \geq x_1$ .

15

59. The computer readable medium as claimed in claim 52, if a data sequence which is embedded as said digital watermark data is modulated by a pseudo-random sequence, said computer readable medium further comprising:

20

program code means for obtaining a binary distribution function  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits are included in a bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a repeating number  $t$  of embedding each bit of digital watermark data;

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program code means for reading an  $i$ th digital watermark sequence of said digital watermark data from a digital watermark area of said digital data contents;

35 program code means for demodulating said digital watermark sequence by said pseudo-random sequence;

program code means for assigning  $1/2$  to said probability  $q$ ;

program code means for obtaining  $x_0$  or  $x_1$  which satisfies  $0 \leq F(x=x_0) \leq 1-\alpha$  or  $\alpha \leq F(x=x_1) \leq 1$ ,  $\alpha$  being a threshold of reliability of digital watermark data which is read;

program code means for determining whether a value is equal to or less than  $x_0$  or equal to or more than  $x_1$ , said value being a mean value of absolute values of a difference between the number of '0' or '1' included in said  $i$ th digital watermark sequence and a central value  $q \times t$  of a binary distribution;

program code means for reconstituting digital watermark data by performing majority decision processing for said  $i$ th digital watermark sequence if said value is equal to or less than  $x_0$  or equal to or more than  $x_1$ ; and

program code means for determining that there is no digital watermark data or the presence is unknown if said value is not equal to or less than  $x_0$  or equal to or more than  $x_1$ .

25

60. The computer readable medium as claimed in claim 59, further comprising:

program code means for calculating a value of said binary distribution function  $F(z)$ ,  $z$  being said mean value obtained from the number of '0' or '1' included in said  $i$ th digital watermark sequence and said central value  $q \times t$ ; and

program code means for outputting said value of  $F(z)$  as reliability of digital watermark data.

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61. A method for reading digital watermark  
5 data from digital data contents in which each bit of  
digital watermark data is embedded a plurality of  
times, said method comprising the steps of:  
receiving digital data contents;  
reading a digital watermark sequence from  
10 said digital data contents;  
performing soft decision in code theory by  
assigning weights to said digital watermark sequence  
with a weighting function; and  
reconstituting and generating digital  
15 watermark data from said digital watermark sequence.

20 62. The method as claimed in claim 61,  
wherein said weighting function is a distribution  
function obtained by a method comprising the steps  
of:  
dividing first digital data contents into  
25 one or a plurality of first block data;  
dividing second digital data contents into  
one or a plurality of second block data, said second  
digital data contents being obtained by manipulating  
said first digital data contents with a  
30 predetermined manipulation method;  
transforming said first block data and  
said second block data into first frequency  
coefficients and second frequency coefficients  
respectively by applying an orthogonal transform;  
35 and  
obtaining a distribution of difference  
values between said first frequency coefficients and



said second frequency coefficients, said distribution function being an approximation of said distribution,

5 wherein said weights are assigned to said digital watermark sequence according to values of said distribution function.

10

63. The method as claimed in claim 61, wherein said weighting function is a distribution function obtained by a method comprising the steps of:

15 dividing first digital data contents into one or a plurality of first block data;

dividing second digital data contents into one or a plurality of second block data, said second digital data contents being obtained by manipulating  
20 said first digital data contents with a predetermined manipulation method;

transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients  
25 respectively by applying an orthogonal transform; and

obtaining said distribution function on the basis of a theory if a distribution of difference values between said first frequency  
30 coefficients and said second frequency coefficients can be obtained by said theory,

wherein said weights are assigned to said digital watermark sequence according to values of said distribution function.

35

64. An apparatus for reading digital watermark data from digital data contents in which each bit of digital watermark data is embedded a plurality of times, said apparatus comprising:  
means for receiving digital data contents;  
means for reading a digital watermark sequence from said digital data contents;  
means for performing soft decision in code theory by assigning weights to said digital watermark sequence with a weighting function; and  
means for reconstituting and generating digital watermark data from said digital watermark sequence.

15

65. The apparatus as claimed in claim 64, wherein said weighting function is a distribution function obtained by means comprising:

means for dividing first digital data contents into one or a plurality of first block data;  
means for dividing second digital data contents into one or a plurality of second block data, said second digital data contents being obtained by manipulating said first digital data contents with a predetermined manipulation method;  
means for transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal transform; and  
means for obtaining a distribution of difference values between said first frequency coefficients and said second frequency coefficients,

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said distribution function being an approximation of said distribution,

wherein said weights are assigned to said digital watermark sequence according to values of said distribution function.

10                    66. The apparatus as claimed in claim 64,  
wherein said weighting function is a distribution  
function obtained by means comprising:  
                    means for dividing first digital data  
                    contents into one or a plurality of first block  
15                   data;  
                    means for dividing second digital data  
                    contents into one or a plurality of second block  
                    data, said second digital data contents being  
                    obtained by manipulating said first digital data  
20                   contents with a predetermined manipulation method;  
                    means for transforming said first block  
                    data and said second block data into first frequency  
                    coefficients and second frequency coefficients  
                    respectively by applying an orthogonal transform ;  
25                   means for obtaining said distribution  
                    function on the basis of a theory if a distribution  
                    of difference values between said first frequency  
                    coefficients and said second frequency coefficients  
                    can be obtained by said theory, and  
30                   wherein said weights are assigned to said  
                    digital watermark sequence according to values of  
                    said distribution function.

35

67. An integrated circuit for reading

digital watermark data from digital data contents in which each bit of digital watermark data is embedded a plurality of times, said integrated circuit comprising:

- 5                   means for receiving digital data contents;  
                  means for reading a digital watermark  
sequence from said digital data contents;  
                  means for performing soft decision in code  
theory by assigning weights to said digital  
10 watermark sequence with a weighting function; and  
                  means for reconstituting and generating  
digital watermark data from said digital watermark  
sequence.

15

68. The integrated circuit as claimed in claim 67, wherein said weighting function is a
- 20 distribution function obtained by means comprising :  
                  means for dividing first digital data  
contents into one or a plurality of first block  
data;  
                  means for dividing second digital data  
25 contents into one or a plurality of second block  
data, said second digital data contents being  
obtained by manipulating said first digital data  
contents with a predetermined manipulation method;  
                  means for transforming said first block  
30 data and said second block data into first frequency  
coefficients and second frequency coefficients  
respectively by applying an orthogonal transform;  
and  
                  means for obtaining a distribution of  
35 difference values between said first frequency  
coefficients and said second frequency coefficients,  
said distribution function being an approximation of

said distribution,

wherein said weights are assigned to said digital watermark sequence according to values of said distribution function.

5

69. The integrated circuit as claimed in claim 67, wherein said weighting function is a distribution function obtained by means comprising:

means for dividing first digital data contents into one or a plurality of first block data;

15 means for dividing second digital data contents into one or a plurality of second block data, said second digital data contents being obtained by manipulating said first digital data contents with a predetermined manipulation method;

20 means for transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal transform; and

25 means for obtaining said distribution function on the basis of a theory if a distribution of difference values between said first frequency coefficients and said second frequency coefficients can be obtained by said theory,

30 wherein said weights are assigned to said digital watermark sequence according to values of said distribution function.

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70. A computer readable medium storing

program code for causing a computer system to read digital watermark data from digital data contents in which each bit of digital watermark data is embedded a plurality of times, said computer readable medium  
5 comprising:

program code means for receiving digital data contents;

program code means for reading a digital watermark sequence from said digital data contents;

10 program code means for performing soft decision in code theory by assigning weights to said digital watermark sequence with a weighting function; and

program code means for reconstituting and  
15 generating digital watermark data from said digital watermark sequence.

20

71. The computer readable medium as claimed in claim 70, wherein said weighting function is a distribution function obtained by program code means comprising:

25 program code means for dividing first digital data contents into one or a plurality of first block data;

program code means for dividing second digital data contents into one or a plurality of  
30 second block data, said second digital data contents being obtained by manipulating said first digital data contents with a predetermined manipulation method;

program code means for transforming said  
35 first block data and said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal

transform; and

program code means for obtaining a distribution of difference values between said first frequency coefficients and said second frequency coefficients, said distribution function being an approximation of said distribution,

wherein said weights are assigned to said digital watermark sequence according to values of said distribution function.

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72. The computer readable medium as claimed in claim 70, wherein said weighting function is a distribution function obtained by program code means comprising:

program code means for dividing first digital data contents into one or a plurality of first block data;

program code means for dividing second digital data contents into one or a plurality of second block data, said second digital data contents being obtained by manipulating said first digital data contents with a predetermined manipulation method;

program code means for transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal transform; and

program code means for obtaining said distribution function on the basis of a theory if a distribution of difference values between said first frequency coefficients and said second frequency coefficients can be obtained by said theory,

wherein said weights are assigned to said

digital watermark sequence according to values of  
said distribution function.

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